Road Improvement Program

ROAD SAFETY AUDIT

MUNICIPAL PILOT PROGRAM

SUMMARY REPORT

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Executive Summary

The Insurance Corporation of British Columbia has been promoting the benefits of Road Safety Audits (RSA) since 1997. In year 2001, ICBC started a Municipal RSA Pilot Program to partner with British Columbia municipalities to pilot road safety audits, with the long term goal of incorporating RSA as part of the process in the delivery of road transportation projects for municipalities in British Columbia. The road safety audits that were completed within the Pilot Program were carried out following the procedures set out in the Transportation Association of Canada's Canadian Road Safety Audits Guide, December 2001.

The Pilot Program objectives are to:

- Promote the use of Road Safety Audit as a cost-effective tool to address safety on municipal roads;
- Raise the safety awareness of roadway design by municipal engineers;
- Prevent the construction of potentially hazardous design features and encourage the construction of more forgiving roadways on municipal networks; and
- Provide resources and skills for local municipalities to pilot road safety audits.

A total of 19 projects were selected for the Pilot Program from 14 municipalities. The projects included new road constructions, major rehabilitation, intersection improvements, road widening, and on-road bicycle facilities. In-service road safety audits were explicitly excluded from the Pilot Program since these projects are considered to be better addressed through the Road Improvement Program's Retrofit Program. Project costs ranged between $25,000 and $15 million. The design stages selected for the pilot projects included:

- Feasibility stage: 2 projects;
- Preliminary stage: 7 projects;
- Detailed Design stage: 8 projects; and
- Pre-/Post-construction stage: 2 projects.

The results of the Pilot Program provided the following observations:

- All the participants agreed that the road safety audits conducted for the pilot projects resulted in improvements to the overall safety of the projects.

- The majority of the participating municipalities were supportive of the Pilot Program, and have indicated various degrees of commitments to conduct more road safety audits in the future for their capital projects.

- A number of municipalities have indicated that they would consider developing their own policies to institutionalize the road safety audit process.

- Some issues would need to be addressed to further promote road safety audits for municipalities. These issues include liability, training, and resources.

- The additional costs incurred by the safety audits (in order to address the identified safety issues) were found to be no more than $50,000, and were typically less than $10,000. On the average, the costs of the audits (including additional implementation costs to accommodate the audit suggestions) did not exceed 1 percent of the overall project cost.

- The results from the cursory benefit-cost analysis indicated that road safety audits achieved an overall benefit-cost ratio of at least 4.1:1 over a 2-year period using average ICBC collision costs, and could be as high as 32.9:1 over a 10-year period using provincial collision costs. Although the benefit-cost analysis may be subjective in its nature, it yielded results that were similar to results from other international reviews.

- It is obvious that the cost of conducting road safety audits is relatively minor in proportion to the overall costs of most road transportation projects. It is reasonable to conclude that road safety audits yield substantial safety benefits to the community and ICBC in both safety and economic terms.

For year 2002, it is recommended that the Pilot Program be continued to facilitate the following goals:

- Conduct road safety audits for a number of the 2001 pilot projects that will be proceeding into the next stages of design. This would provide some indications of the potential benefits and costs of conducting safety audits at incremental planning and design stages of a project.

- Conduct road safety audits for new municipal partners, and to broaden the exposure and sample size available for evaluation.

- Refine the benefit-cost analysis by making use of the newly developed collision prediction models, and collision reduction factors (ISCER) by ICBC, and alternate methods to assign road safety risk.

- Promote and assist municipalities to develop their own road safety audit policies through partnerships with ICBC.

1.0 INTRODUCTION

The Insurance Corporation of British Columbia has been promoting the benefits of Road Safety Audits (RSA) since 1997. ICBC's Road Improvement Program has sponsored a number of research papers, projects, seminars and workshops with the assistance of a local safety engineering consultant (Hamilton Associates) and international road safety audit experts (Mr. Philip Jordan of VicRoads, and Mr. Steve Proctor and Mr. Malcolm Bulpitt of TMS Consultancy U.K.). As a result of ICBC's promotional efforts, the B.C. Ministry of Transportation (MoT) initiated a Pilot Project to evaluate the RSA process in 1999.

A number of Road Safety Audits have also been conducted for various municipalities in the Province, including the Richmond-Vancouver Median Bus Lanes along No. 3 Road, the Skytrain Extension along Lougheed Highway in Burnaby, and the Stanley Park S-curve Improvement in Vancouver.

However, most local municipalities have limited resources to conduct or pilot road safety audits, thus hindering the growth and popularity of an effective road safety engineering tool. Thus, in year 2001, ICBC started a Municipal RSA Pilot Program to partner with British Columbia municipalities to pilot road safety audits, with the long term goal of incorporating RSA as part of the process in the delivery of road transportation projects for municipalities in British Columbia.

1.1 Road Safety Audit

A road safety audit is a process for systematically checking the safety of road transportation projects, based on sound road safety engineering principles and undertaken from the road users' perspectives. A road safety audit is an input to the design process that provides an independent assessment of the safety performance of a road transportation project at predetermined intervals by road safety specialists. It is duly noted that the project design team remains ultimately responsible for the design. The Canadian Road Safety Audit Guide, published by the Transportation Association of Canada (TAC) in 2001, defines a road safety audit as follows:

> *A road safety audit is a formal and independent safety performance review of a proposed road transportation project by an experienced team of safety specialists, addressing the safety for all road users.*

The objectives of a road safety audit are to:

- minimize the frequency and severity of preventable collisions;
- consider the safety of all road users, including vulnerable road users;
- ensure that collision mitigation measures that may eliminate or reduce the identified safety problems are considered fully; and to,
- minimize potentially negative safety impacts outside the project limits, i.e. to avoid introducing collisions elsewhere along the route or on the network.

The road safety audits that were completed within the Pilot Program were carried out following the procedures set out in the Transportation Association of Canada's Canadian Road Safety Audits Guide, December 2001. The road safety audits covered physical features of the proposed design that may affect road user safety and the audits seek to identify potential safety hazards.

1.2 Program Objectives

The Program objectives are to:

- Promote the use of Road Safety Audit as a cost-effective tool to address safety on municipal roads;
- Raise the safety awareness of roadway design by municipal engineers;
- Prevent the construction of potentially hazardous design features and encourage the construction of more forgiving roadways on municipal networks; and
- Provide resources and skills for local municipalities to pilot road safety audits.

1.3 Pilot Program Process

The Pilot Program followed a systematic process as described below:

1. A 2-day seminar was conducted in January 2001 to familiarize municipal engineers with the road safety audit process and procedures.
2. Each participating municipality nominated up to 2 projects for the Pilot Program. The nomination process was completed by April 2001.

3. The pilot projects were selected in May 2001, and a road safety audit team was appointed for each project.

4. Data such as project size, safety issues, audit suggestions, audit cost, and design team responses to the audit suggestions were collected for each audit for the purposes of evaluation.

5. A roundtable discussion seminar was held in August 2001 with municipal engineers to discuss the various issues that surfaced during the audit process of the pilot projects.

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2.0 MUNICIPAL PILOT PROGRAM

A total of 19 projects were selected as part of the Pilot Program. The projects were audited between March 2001 and January 2002. As mentioned earlier, each project that was audited followed the procedures set out in the TAC's Canadian Road Safety Audit Guide, 2001, and consisted of the following steps (illustrated below in Figure 2.1):

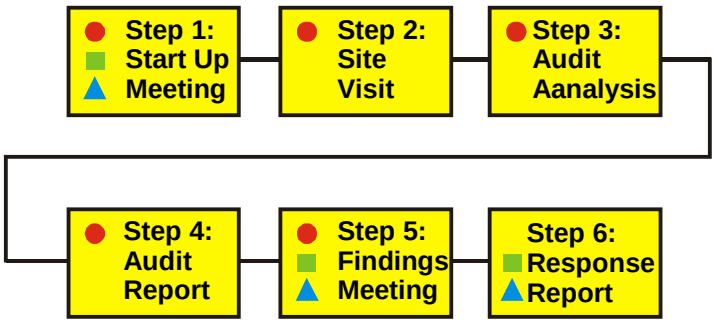
1. Start-up Meeting: The audit team met with the project owner and/or the design team to discuss project details, design challenges, project schedule and to exchange information such as background reports and design drawings.

2. Site Visit: Member(s) of the audit team visited the project site to observe traffic patterns, site and environmental conditions, and interaction between road users.

3. Audit Design: The audit team reviewed the design using established road safety engineering principles. Safety issues that may increase the collision risks were identified and suggestions were made to mitigate the safety issues.

4. Completion Meeting: A completion meeting was held for each project, and the audit team discussed the identified safety issues and the respective audit suggestions with the project owner and/or design team.

5. Response Report: A response report was prepared by the project owner/design team to address issues raised in the audit report. For audit suggestions that were rejected, justifications were provided to support the project owner/design team's decisions.



The Road Safety Audit Process as described in TAC's Canadian Road Safety Audit Guide, 2001

Responsibilities:
- Audit Team
- Design Team
- Project Owner

Figure 2.1 The Road Safety Audit Process

2.1 Pilot Projects

A total of 19 projects were selected for the Pilot Program from 14 municipalities. The projects included new road constructions, major rehabilitation, intersection improvements, road widening, and on-road bicycle facilities. In-service road safety audits were explicitly excluded from the Pilot Program since these projects are considered to be better addressed through the Road Improvement Program's Retrofit Program. Project costs ranged between $25,000 and $15 million. The design stages selected for the pilot projects included:

- Feasibility stage: 2 projects;
- Preliminary stage: 7 projects;
- Detailed Design stage: 8 projects; and
- Pre-/Post-construction stage: 2 projects.

A summary of the Pilot Projects is provided in Table 2.1, and a sample of the pilot projects for various audit stages are shown in Figure 2.2.

2.2 Audit Team

The audit team consist of Geoffrey Ho (Team Leader) and Paul de Leur of ICBC's Road Improvement Program for 12 of the 19 projects. The remainder of the projects (seven projects) was contracted to and audited by Hamilton Associates.

2.3 Data Collection

Data for the evaluation undertaken in this report were collected from several sources, including:

1. Road Safety Audit reports by RSA Team: identified the safety issues and suggestions for improvement.
2. Response reports by municipalities/design consultants: provided the number of audit suggestions accepted and rejected and the reasons why.
3. Survey Questionnaire: provided subjective opinions and feedback, project savings or additional costs as a result of the audit.
4. Time and Contract Tracking: the time required for the ICBC audit team to conduct each audit and the costs of each audit conducted by consultant was tracked.

At the time of preparation of this report, 13 response reports were collected and 14 questionnaires were received.

Table 2.1 Municipal Road Safety Audit Pilot Project Summary

Audit Stage	Municipality	Project Name	Project Cost	Designer	Audit Team
Feasibility	Kamloops	Hillside Drive Upgrading	$1.7 million	Consultant	ICBC
	Kamloops	Mission Flats Fog Mitigation	$700,000	Consultant	ICBC
Preliminary Design	Kelowna	North End Connector	$15 million	Consultant	ICBC
	City of N. Vancouver	W. Esplanade & Low Level	$25,000	Staff	ICBC
	Saanich	Wilkinson and Helmcken	$1.8 million	Staff	ICBC
	Saanich	West Saanich and Wilkinson	$450,000	Staff	ICBC
	Vancouver	Boundary and 1st	$200,000	Staff	ICBC
	Vancouver	Grandview and Skeena	$ 1 million	Staff	ICBC
	White Rock	Roper Avenue Upgrading	$400,000	Consultant	ICBC
Detailed Design	Burnaby	Marine Way/10th Ave Connector	$6.5 million	Consultant	ICBC
	Delta	River Road East Phase 2A and B	$2.5 million	Consultant	Hamilton Associates
	Coquitlam	United Boulevard Extension	$4.8 million	Consultant	ICBC
	Port Moody	North Shore Arterial Roads	$11.7million	Consultant	Hamilton Associates
	Township of Langley	16th Avenue Improvements	$700,000	Consultant	Hamilton Associates
	Township of Langley	64th Avenue Widening	$1.5 million	Consultant	Hamilton Associates
	Surrey	Scott Road: 96 to 103A Ave	$12 million	Consultant	Hamilton Associates
	Victoria	Finlayson Street: Bicycle Lanes	$460,000	Staff	ICBC
Pre-opening	District of N. Vancouver	Dollarton Hwy Realignment	$5 million	Consultant	Hamilton Associates
Post-construction	City of N. Vancouver	West 1st Street Overpass	n.a.	Consultant	Hamilton Associates

Mission Flats in Kamloops, Feasibility Stage Audit

Wilkinson & Helmcken in Saanich, Preliminary Design Stage Audit

Finlayson St. in Victoria, Detailed Design Stage Audit

United Blvd. Extension in Coquitlam, Detailed Design Stage Audit

Figure 2.2 Sample of Pilot Projects for Various Audit Stages

3.0 PILOT PROGRAM RESULTS

The results of the Pilot Program were grouped into five different categories:

- Identified Safety Issues
- Safety Audit Suggestions
- Audit Stages
- Lessons Learned
- Benefit-Cost Evaluation

A detailed discussion of each category is provided in this section.

3.1 Identified Safety Issues

In general, each road safety audit identified between 10 and 35 safety issues. Overall, approximately 370 safety issues were identified for the 19 pilot projects. Of all the identified safety issues, 49 percent were traffic operations related issues, such as traffic signal operations, pedestrian and cyclist facilities, lighting, and access. 34 percent of the safety issues identified were related to geometric design elements, such as barrier design, roadside treatment, lane widths, curve radius, and sight distance. 15 percent of the safety issues identified were related to signage and pavement markings, such as placement of signs, and the treatment of pavement markings. The remaining 2 percent of safety issues were speed-related problems, such as the potential for speeding and provision of enforcement bays/area. The results are summarized in Table 3.1.

Table 3.1 Distribution of Identified Safety Issues

Identified Safety Issues	Percent of Total
Traffic Operations	49%
Geometric Design	34%
Signage and Pavement Markings	15%
Speed	2%

Thus, approximately 65 percent of safety issues identified were traffic operations and control devices related. This proportion of safety issues may be attributed to the lack of traffic engineering input in the design process, and possibly the high number of detailed design and pre-/post-opening stage audits that were completed within the pilot program.

Furthermore, the identified safety issues were categorized into different road user groups. The results indicated that 72 percent of the safety issues were automobile-related issues, 19 percent were pedestrian-related issues, 8 percent were cyclist-related issues, and the remaining 1 percent were related to other road users such as motor cyclists and equestrians. The results are summarized in Table 3.2.

Table 3.2 Distribution of Identified Safety Issues by Road User

Identified Safety Issues	Percent of Total
Motorist	72%
Pedestrian	19%
Cyclist	8%
Others	1%

Based on the questionnaires that were returned, the majority of municipal participants felt that most identified safety issues were:

- identified before the audit;
- relevant to the design stages; and
- adequately explained by the audit team.

A number of safety issues were repeated in several reports due to the municipal standards specified in the Master Municipal Construction Document (MMCD) prepared by the Municipal Engineers Division of the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). The safety issues included the treatment of "wheelchair" or curb ramps at intersections and the usage of frangible light poles.

3.2 Road Safety Audit Suggestions

Based on the response reports returned by the Pilot Program participants, an average of 66 percent of the audit suggestions were accepted and led to changes in the design. The acceptance rate ranged between 31 and 100 percent between individual audit reports.

The results of the questionnaire survey indicated that:

- The audit suggestions were all or mostly valid;
- All or most audit suggestions were appropriate to the design stage;
- Some form of risk assessment may be needed to prioritize audit suggestions; and
- 92 percent of the projects resulted in some degree of redesign.

3.3 Road Safety Audit Stages

Based on the results of the questionnaire survey, 70 percent of the participants indicated that a safety audit conducted at an earlier stage would be beneficial. As well, 30 percent of participants indicated that a later stage audit would also be beneficial, while 54 percent indicated that an audit might be beneficial at a later design stage (i.e., 84 percent of the participants felt that a later stage audit would be or may be beneficial).

It became obvious in the detailed design stage audits that the majority of the design elements or criteria could not be modified due to right-of-way or cost constraints. Thus, an audit conducted in an earlier design stage would have been beneficial in allowing the design team to justify whether certain design criteria was appropriate and whether a change to the design criteria would have led to a "safer" design.

3.4 Lessons Learned

The returned questionnaires provided a substantial amount of subjective feedback by the participants. Overall the majority of the participants indicated that the pilot program provided a positive experience and illustrated the benefits of road safety audits. The results of the questionnaire survey are highlighted below.

- None of the participants indicated that road safety audits was not cost-effective.

- 85 percent of the participants indicated that conducting a road safety audit would assist to gain Council's and the Public's acceptance of the project.

- All participants indicated that the road safety audit process added value to the design and felt that the audit improved the overall safety of the project.

- All participants indicated that they would consider more RSA in the future, while 40 percent of the participants would consider developing their own municipal policy to conduct road safety audits.

- All participants would continue to support a road safety audit program sponsored by ICBC, and considered the road safety audit process to be supportive of ICBC's mission statement "to help British Colombians take the risk out of road transportation".

3.5 Audit Costs

Costs related to the road safety audit pilot projects were monitored. These costs include audit costs in consulting fees or staff time, staff time spent by municipal engineers and additional fees required to address audit suggestions by design consultants (i.e., design fees).

A. Audit Costs

The time required for the ICBC Team to conduct safety audits for the pilot projects ranged between 30 and 65 hours. Assuming the hourly rate of an auditor is $125, the typical costs of an audit would range between $3,750 and $8,125. The consulting fees on the pilot projects conducted by Hamilton Associates were very similar, ranging between $4,000 and $7,500. The average cost of an audit conducted within the Pilot Program is approximately $5,000.

B. Municipal Staff Time and Design Consultant Fees

Based on the returned questionnaires, the resources dedicated by the municipalities are summarized in Table 3.3. The results indicated that one or two days of staff time is typically spent on the pilot project, while additional design consultant fees cost no more than $5,000 for each project.

Table 3.3 Municipal Resources Dedicated to Pilot Project

Staff Time	Percent	Additional Consultant Fees	Percent
Less than 1 day	8%	Less than $500	23%
1 day	38%	Less than $1,000	38%
2 days	23%	Less than $5,000	39%
More than 2 days	31%	More than $5,000	0%

C. Changes in Project Costs

Of the 13 pilot projects audited and responded to, one project resulted in a cost saving of $25,000. Two projects did not result in additional costs or cost savings. Nine projects resulted in additional costs, and the additional cost to the project (in order to address the identified safety issues) were typically less than $10,000. The distribution of projects with additional implementation costs is summarized in Table 3.4.

Table 3.4 Summary of Additional Project Costs (based on 9 projects)

Project Cost	Percent of Pilot Projects
Less than $5,000	34%
Less than$10,000	44%
Less than $25,000	11%
Less than$50,000	11%

D. Total Costs

The total costs of the audits were determined and summarized in Table 3.5. The results were provided for total costs where the additional costs of implementation were included and excluded. The results indicated that the overall costs of the audits within the Pilot Program accounted for approximately 0.5 percent of the project costs (including additional implementation costs to accommodate the audit suggestions). On the average, the costs of the audits (including additional implementation costs to accommodate the audit suggestions) did not exceed 1 percent of the overall project cost.

Table 3.5 Summary of Total Costs for Pilot Projects

Project	Project Cost	Audit Costs (Excluding Implementation Costs)	Percent of Total Project Cost (Excluding Implementation Costs)	Audit Cost (Including Implementation Costs)	Percent of Total Project Cost (Including Implementation Costs)
1	$4,800,000	$6,300	0.1%	$11,300	0.2%
2	$6,500,000	$6,150	0.1%	$16,150	0.2%
3[a]	$400,000	$5,325	1.3%	$5,325	1.3%
4	$1,000,000	$3,700	0.4%	$13,700	1.4%
5	$200,000	$3,700	1.9%	$13,700	6.9%
6	$25,000	$3,900	15.6%	$13,900	55.6%
7	$460,000	$4,150	0.9%	$4,150	0.9%
8	$1,500,000	$6,800	0.5%	$31,800	2.1%
9	$700,000	$6,800	1.0%	$6,800	1.0%
10	$11,700,000	$8,900	0.1%	n.a.	0.1%
11	$2,500,000	$10,400	0.4%	$15,400	0.6%
12[b]	n.a.	$6,200	n.a.	$11,200	n.a.
13	$5,000,000	$11,400	0.2%	$21,400	0.4%
Average[c]	**$2,900,000**	**$6,440**	**0.6%**	**$13,735**	**0.9%**
Overall	$34,785,000	$83,725	0.2%	$164,825	0.5%

note: [a] this project resulted in cost savings, thus was treated as no additional implementation costs.
[b] the capital cost of this project was unavailable.
[c] project 6 was excluded from the percent calculation.

3.6 Road Safety Audit Benefits

The benefits associated with road safety audits were estimated for the Pilot Program, and the benefits were compared with benefits reported in the literature. The details are described in the following sections of the report.

A. Results from the Pilot Program

The safety benefits of the pilot projects were estimated using the risk assessment methodology as described in the Canadian Road Safety Audit Guide published by TAC. A more detailed analysis of the collision reduction potential was not performed at this time due to the lack of information such as traffic volume, and historical collision characteristics for most projects. The risk assessment methodology is expected to provide a cursory estimate of the potential safety benefits of the safety audits. However, it is recognized that the risk assessment methodology involved some degree of subjectivity in the estimating the safety benefits. Thus, a conservative approach was taken when conducting the risk assessment to reduce the likelihood of overestimating the benefits of the safety audit suggestions and the resulting design changes.

The TAC Guide suggested a risk assessment matrix for prioritizing road safety audit suggestions as shown in Table 3.6. The matrix was based on the frequency and severity of potential collisions associated with each identified safety issue.

Table 3.6 TAC Risk Assessment Matrix

Collision Severity	Collision Frequency		
	>1 per year	>1 per 5 years	>1 per 10 years
Fatal	High	High	High
Injury	High	Medium	Medium
Property Damage	Medium	Low	Low

The TAC matrix was modified to reflect the potential collision reduction of the accepted audit suggestion as shown in Table 3.7. Thus, an accepted suggestion that resulted in certain design changes may be assigned one of the nine possible combinations of collision reduction potential as shown in Table 3.7.

Table 3.7 Modified Risk Assessment Matrix

Collision Severity	Collision Reduction Potential		
Fatal	1 per year	1 per 5 years	1 per 10 years
Injury	1 per year	1 per 5 years	1 per 10 years
Property Damage	1 per year	1 per 5 years	1 per 10 years

Each accepted audit suggestion was reviewed and was assigned a collision reduction value using the matrix shown in Table 3.8. For example, an audit suggested increasing the lateral clearance between light poles and the roadway. The suggestion was incorporated into the design, and a saving of one injury collision per 5 years was assigned as the potential collision reduction or benefit of the resulting changes. This is because the likelihood of a collision resulting in is high, but the collision frequency is moderate to low. Examples of estimating the collision reduction potential of the accepted audit suggestions are provided in Table 3.8. Fatal collisions are considered highly random events, therefore fatal collisions were not used in the estimation of collision reduction in order to maintain a conservative approach to the estimates.

Table 3.8 Examples of Collision Reduction Estimates

Accepted Audit Suggestion	Estimated Collision Reduction Potential
Provide protected only or protected-permissive left-turn phase	1 injury collision per year
Increase lateral clearance between lighting poles and travel lane	1 injury collision per 5 years
Extend roadside barriers and provide appropriate flare	1 injury collision per 10 years
Pave overpass with anti-skid material to reduce rear-end collisions	1 property damage collision per year
Provide pavement guidance markings for dual left-turn lanes	1 property damage collision per 5 years
Restrict access with physical means to T intersection	1 property damage collision per 10 years

The potential safety benefit of each accepted audit suggestion for each pilot project was estimated using this approach. The results are aggregated for each pilot project, and the resulting reduction in collision frequency and the associated costs are summarized in Table 3.9. The results shown were calculated using two different collision costs: the ICBC average collision costs, and the 1997 collision costs used by the Ministry of Transportation. The ICBC costs used were $44,000 for an injury collision and $4,500 for a property damage only collision. The Ministry costs used were $97,000 for an injury collision and $6,000 for a property damage only collision. An interest rate of 8 percent was assumed to calculate the present worth of the safety benefits. Service lives of 10 and 5 years were used in calculating the Net Present Value of the potential safety benefits. It was assumed that most of the audit suggestions would have a service life of up to 10 years. A 2-year service life using ICBC costs was also used to compare with ICBC's investment criteria of 2:1 return over 2 years.

Table 3.9 Summary of Potential Safety Benefits of Pilot Projects

Project	Estimated Collision Reduction per year		10-year Service Life		5-year Service Life		2-year Service Life
	Injury Collision	PDO Collision	ICBC Costs	MoT Costs	ICBC Costs	MoT Costs	ICBC Costs
1	1.4	1.6	$461,654	$975,646	$274,698	$580,540	$122,689
2	1	0.2	$301,283	$658,930	$179,273	$392,084	$80,069
3	0.4	0.2	$124,137	$268,403	$73,865	$159,708	$32,990
4	1.1	1.2	$361,002	$764,278	$214,808	$454,770	$95,940
5	0.7	1.2	$242,905	$503,927	$144,536	$299,853	$64,554
6	0.7	0.2	$212,710	$463,667	$126,569	$275,896	$56,529
7	0.5	0.6	$165,739	$349,595	$98,620	$208,020	$44,047
8	0.4	0.5	$133,195	$280,481	$79,255	$166,895	$35,398
9	0.5	0.1	$150,641	$329,465	$89,636	$196,042	$40,034
10	0.8	1.2	$272,429	$569,015	$162,104	$338,582	$72,401
11	0.1	0.2	$35,563	$73,140	$21,161	$43,521	$9,451
12	0.5	0.3	$156,680	$337,517	$93,230	$200,833	$41,639
13	0.6	0.7	$198,283	$418,709	$117,985	$249,145	$52,695
Overall	**8.7**	**8.2**	**$2,816,221**	**$5,992,774**	**$1,675,740**	**$3,565,889**	**$748,436**

Using the results from Tables 3.5 and 3.9, the benefit-cost ratio for the pilot projects were determined and summarized in Table 3.10.

The results indicated that using ICBC collisions costs, the overall benefit-cost ratios ranged between 4.1:1 and 15.4:1 (2 years to 10 years service life) when the additional costs of implementing safety improvements were included. Of the 12 pilot projects that were evaluated, only one project resulted in a benefit-cost ratio of lower than 1:1, i.e., did not breakeven. Furthermore, the overall benefit-cost ratio for a 2-year service life ranged between 4.1:1 (including additional implementation costs) to 8.9:1 (excluding additional implementation costs), and clearly indicated that the return on investment far exceeded ICBC's investment criteria of 2:1 return in 2 years.

Using MoT collisions costs, the overall benefit-cost ratios ranged between 19.6:1 and 32.9:1, for 5 years and 10 years of service life, respectively. These benefit-cost ratios included the additional costs of implementing safety improvements. Of the 12 pilot projects that were evaluated, all projects resulted in benefit-cost ratios of higher than 1:1. The benefit-cost ratios were obviously higher when the costs of implementing additional changes were excluded.

Table 3.10 Summary of Estimated Benefit-Cost Ratios for Pilot Projects

Project	Excluding Implementation Costs					Including Implementation Costs				
	10 years		5 years		2 years	10 years		5 years		2 years
	ICBC	MoT	ICBC	MoT	ICBC	ICBC	MoT	ICBC	MoT	ICBC
1	73.3	154.9	43.6	92.1	19.5	40.9	86.3	24.3	51.4	10.9
2	49.0	107.1	29.2	63.8	13.0	18.7	40.8	11.1	24.3	5.0
3	23.3	50.4	13.9	30.0	6.2	23.3	50.4	13.9	30.0	6.2
4	97.6	206.6	58.1	122.9	25.9	26.4	55.8	15.7	33.2	7.0
5	65.6	136.2	39.1	81.0	17.4	17.7	36.8	10.6	21.9	4.7
6	54.5	118.9	32.5	70.7	14.5	15.3	33.4	9.1	19.8	4.1
7	39.9	84.2	23.8	50.1	10.6	39.9	84.2	23.8	50.1	10.6
8	19.6	41.2	11.7	24.5	5.2	4.2	8.8	2.5	5.2	1.1
9	22.2	48.5	13.2	28.8	5.9	22.2	48.5	13.2	28.8	5.9
10	30.6	63.9	18.2	38.0	8.1	n.a.	n.a.	n.a.	n.a.	n.a.
11	3.4	7.0	2.0	4.2	0.9	2.3	4.7	1.4	2.8	0.6
12	25.3	54.4	15.0	32.4	6.7	14.0	30.1	8.3	17.9	3.7
13	17.4	36.7	10.3	21.9	4.6	9.3	19.6	5.5	11.6	2.5
Overall	**33.6**	**71.6**	**20.0**	**42.6**	**8.9**	**15.4**	**32.9**	**9.2**	**19.6**	**4.1**

B. Other Studies

A number of international studies have attempted to quantify the actual benefits of safety auditing, and they are summarized in the literature[1] and are quoted below:

- *"A study by Surrey County Council (a UK Highway Authority) which compared 10 low-cost improvement schemes that had received a safety audit with 10 similar schemes that were not audited indicated that the audited schemes had on average one casualty/year less than the unaudited ones."*

- *"A Danish Road Directorate pilot study of 13 schemes showed an estimated 147% First Year Rate of Return for carrying out safety audit. This came from comparing the predicted accident savings versus the audit cost plus the cost of the recommended changes. In this study the audit costs were 0.5% of the total construction costs on comparatively small schemes."*

[1] M. Bulpitt, *Prevention is better than cure: An International Overview of Safety Audit*, Prepared for the 2000 ICBC Road Safety Audit Seminar.

- *"A study by the Transport Research Laboratory in the UK of some 22 safety audited schemes showed a saving per scheme of £11,000 if changes were made at Stage 1 or 2 rather than making the changes after completion in response to safety problems. The average cost of each audit was £2,000."*

- *"Information seen from New Zealand claims that a detailed series of safety audits on a scheme could give a cost benefit return in accident savings of at least 20:1 on the audit cost."*

- *"Studies have shown that the average cost of each stage of a safety audit in the UK is estimated at between £500 and £5,000 giving a total audit cost on a scheme for all three stages of between £1,500 and £15,000. This should be compared with the average cost of an injury accident in the UK of some £70,000 and some £1million for a fatality."*

The benefit-cost analysis results of the Pilot Program are in the same order of magnitude compared to results from other international reviews. It demonstrated that Road Safety Audits can be a cost-effective tool to address road safety, particularly in the planning and design process.

4.0 CONCLUSIONS AND NEXT STEPS

In conclusion, the following observations were drawn from the Pilot Program:

- All the participants agreed that the road safety audits conducted for the pilot projects resulted in improvements to the overall safety of the projects.

- The majority of the participating municipalities were supportive of the Pilot Program, and have indicated various degrees of commitments to conduct more road safety audits in the future for their capital projects.

- A number of municipalities have indicated that they would consider developing their own policies to institutionalize the road safety audit process.

- Some issues would need to be addressed to further promote road safety audits for municipalities. These issues include liability, training, and resources.

- The additional costs incurred by the safety audits (in order to address the identified safety issues) were found to be no more than $50,000, and were typically less than $10,000. On the average, the costs of the audits (including additional implementation costs to accommodate the audit suggestions) did not exceed 1 percent of the overall project cost.

- The results from the cursory benefit-cost analysis indicated that road safety audits achieved an overall benefit-cost ratio of at least 4.1:1 over a 2-year period using average ICBC collision costs, and could be as high as 32.9:1 over a 10-year period using provincial collision costs. Although the benefit-cost analysis may be subjective in its nature, it yielded results that were similar to results from other international reviews.

- It is obvious that the cost of conducting road safety audits is relatively minor in proportion to the overall costs of most road transportation projects. It is reasonable to conclude that road safety audits yield substantial safety benefits to the community and ICBC in both safety and economic terms.

For year 2002, it is recommended that the Pilot Program be continued to facilitate the following goals:

- Conduct road safety audits for a number of the 2001 pilot projects that will be proceeding into the next stages of design. This would provide some indications of the potential benefits and costs of conducting safety audits at incremental planning and design stages of a project.

- Conduct road safety audits for new municipal partners, and to broaden the exposure and sample size available for evaluation.

- Refine the benefit-cost analysis by making use of the newly developed collision prediction models, and collision reduction factors (ISCER) by ICBC, and alternate methods to assign road safety risk.

- Promote and assist municipalities to develop their own road safety audit policies through partnerships with ICBC.